

IV.—*On the Strata of the Jumna Alluvium, as exemplified in the Rocks and Shoals lately removed from the bed of the river; and of the sites of the Fossil Bones discovered therein. By Serjeant EDMUND DEAN.*

[The Specimens alluded to are deposited in the Society's museum.]

It has always been a matter of speculation with me, since my first acquaintance with the Jumna, that presenting the obstacles to navigation, which it, undoubtedly, does at the present day, after seven years' application of great talent, and a very considerable expenditure, what a gigantic work it must have appeared at its commencement. Experience, however, and a careful research have confirmed me in the opinion, that many of these impediments in one shape or another, were then, and are now, not only such as, their existence once known, could easily be removed, but there is every probability of some of the most dangerous of them being at this instant in a state of active formation and increase.

Taking a general view of the whole, as they occur between Agra and Allahabad, I have found it convenient to class the obstacles most to be dreaded by navigators, as follows :

1st, Clay-banks or shoals; 2nd, Rocks; 3rd, Kankar shoals, and 4th, Sunken trees. This classification is adopted with reference to the supposed degree of danger to the navigation that may be attached to each, a detailed description of which I have endeavoured to arrange in this order.

The grand and perfect section of *the Delta of the Jumna and Ganges*, (or I should rather say, from experience lately gained to the westward, of the immense general alluvium of Hindustan, opened by the channel of the former,) presents a regular alternating stratification of the different modifications of which the general *Dúáb alluvium* is formed; which consists (as far as the section has allowed me to examine), of five distinct strata, interspersed with imbedded substances which from their irregular growth, positions, and occurrence, cannot be classed among the more regular strata. The regular strata occur as follows, namely, 1st, Superior sandstone; 2nd, Shale, and 3rd, 4th, and 5th, Alluvial, (fig. 1. Pl. XIII.)

Only two strata of the superior sandstone occur within the above bounds that I am aware of. The elevated positions of both decidedly have been produced by volcanic irruption, and will be described under the head of rocks.

The Shale which approaches nearest to *d*, var. of *A*. in the first division of McCULLOCH's synopsis, described as passing into clay, appears very seldom. *Note.* The specimens marked "y, 1, 2, and 3," all stand the

test of adhering on being applied to the tongue or lips. (Specs. *y*.)

1st. *Alluvial Clay*, corresponding with *a*, var. of *C.*, first division; is much intersected with seams of kankar $\frac{3}{8}$ of an inch in average diameter, colour dull yellow, grey, and dirty white, and is interstratified with beds of nodule kankar varying between 20 yards, and half a mile in length (as exposed by the river), and from one foot to 15 in thickness.

2nd. *Alluvial Compact Sand* would form a var. *e*, of *C.*, first division; does not agree with *c*, of the same division, as there is no portion of clay, and it is only partially consolidated by the pressure of superincumbent strata. It occurs both above and below the 1st alluvial stratum from 3 to 18 inches thick, and of indefinite length and breadth; in some places a few yards, in others several miles.

3rd. *Alluvial Clay*, with a large proportion of sand *b*, var. of *C.*, first division of Mr. McCULLOCH'S synopsis. This stratum is frequently varied in colour, giving it an appearance of divisibility; but on examination, this difference will be found to extend to colour only, which varies in many places between dull yellow and grey.

1st. Of Clay Banks or Shoals.

These banks (fig. 2. Pl. XIII.) so justly dreaded by navigators of the Jumna, are quite as unwelcome to those engaged on the Jumna works, as their removal is both troublesome and expensive. They are formed of isolated and detached portions of the 1st alluvial stratum, by an accumulation of sand forcing the stream into a new channel, formed by the whole of the 2nd and 3rd alluvials, and least tenacious parts of the 1st alluvium, having been swept away at high levels, leaving such portions of the last as were sufficiently compact to withstand the force of the stream, which are generally those where the natural toughness of the clay is increased by the seam kankar before mentioned, (spec. *x*.) which runs in every direction through it, literally lacing it together, and giving the clay a durability which the action of the strongest current has, perhaps, less effect upon, than it would have on a similar mass of stone of average texture.

The stream, which is generally confined in its course by these obstacles, rushes past them with violence, polishing (as much as clay is capable of such an operation) all those parts exposed to its action.

It was in the crevices formed by the washing away of the softer parts of a bank of this description, (figs. 1 & 2, Pl. XIV.) that the specimen of fossil bones, which were, I believe, presented by Capt. SMITH, and the tulwar, by Lieut. BURT, were found, whilst the clay bank was being removed, the whole upper surface of which was covered with from two to four feet of kankar, of the conglomerate formation. I should wish this to be remembered, as I consider finding the latter in such a



fig. 1.

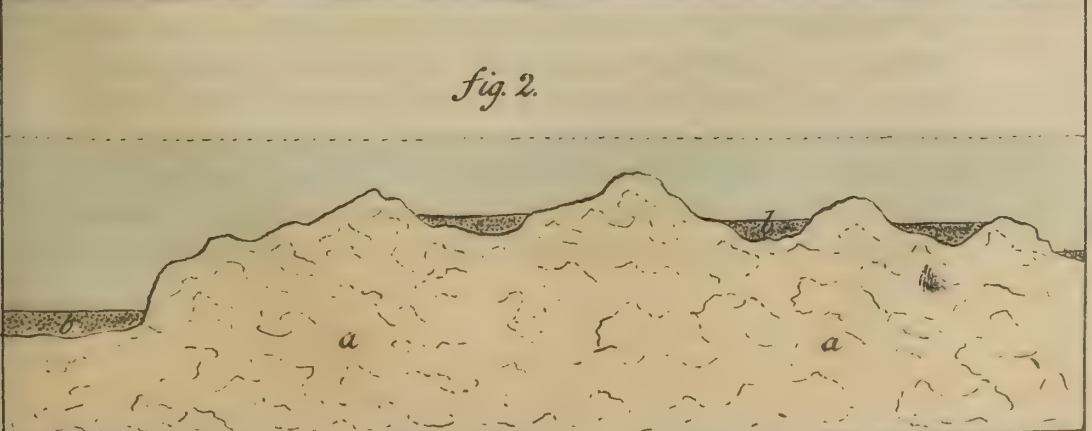


fig. 2.

situation as peculiarly corroborative of my remarks relating both to these banks and to the kankar formation. No instance, however, has ever been known of petrified or fossil animal, or vegetable remains, having been found fairly imbedded in or under this stratum.

Another formation of these banks is occasioned by the current sapping the high and abrupt banks of the river, by washing out the strata of compact sand, when such large masses of stiff clay are detached and thrown into the channel, as to defy the efforts of the stream to dislodge them, which if not speedily effected, a sufficient time has only to elapse to clear the outer parts of the earthy matter which may have fallen with them, which together with sand immediately deposits itself in rear, when every hour secures and strengthens them in their position against the stream, (fig. 3. Pl. XIV.) The interstices (should there be any) are soon filled up with any extraneous substances that may be lodged by the current. Those organic remains which may happen to be imbedded, or rather buried under this sudden deposit, if petrified in that situation, may be easily distinguished, as they invariably adopt in the process of petrification, the hue of the mass with which they are in contact, and which, when the process is complete, nothing will remove, and the porous parts of the bones either remain empty, or are filled with carbonate of lime, infiltrated, whilst in solution. The same remark applies to wood or any other substance. In every other situation the interstices of the fossil to which the water has unrestrained access, is filled with either silicious or argillaceous matter, and frequently with a composition formed of both. For the proper consolidation of either of which, however, the presence of the carbonate of lime is necessary.

Both these formations may be, and frequently are, instanced in one specimen, where from fracture or decomposition, sand or clay may be admitted to one part, when the composition is formed, whilst it is excluded from those more perfect, the pores of which will be either filled with crystallized carbonate, or remain empty as above stated.

By the continual cutting away, and falling in of the banks of the river, the accumulation of alluvial matter in some places is necessarily very extensive. The strength of the current preventing its deposit in the channel, it is carried down to the bend of the river, next below whence it has been dislodged, in the shape of thick sediment, and deposited there; the sand which accompanied its removal is from its greater specific gravity deposited in the bed of the channel. This alluvium forms in banks from 6 to 14 feet thick, and composes, on a rough calculation, not less than 80 or 100,000 acres of arable land, of the first quality, between Agra and Allahabad; producing by

far the best crops of any land in the neighbourhood of the Jumna. Many of these deposits (which occur at every turn of the river) are several feet above its present highest levels; these, however, the river by having deepened in its course since their formation, rather diminishes than increases by washing out those veins of sand, (parallels to the 2nd regular alluvial stratum of the Dúáb general alluvium,) from one to six inches thick, which are invariably interstratified with this deposit: the more compact alluvial stratum above these veins being deprived of their support, separate and fall into the water in flakes, when, if the current is not too violent, the base of another deposit is formed, corresponding to the levels attainable by the river in its present bed, causing the upper surface of the united deposits, either to slope gradually towards the deep part of the channel, or the junction to be marked by a step or steep slope. All those, however, which are covered with only a few inches of water at the highest levels receive an additional deposit of sediment, which, however trifling, answers the purposes of the best manure.

2nd. Of the Rocks.

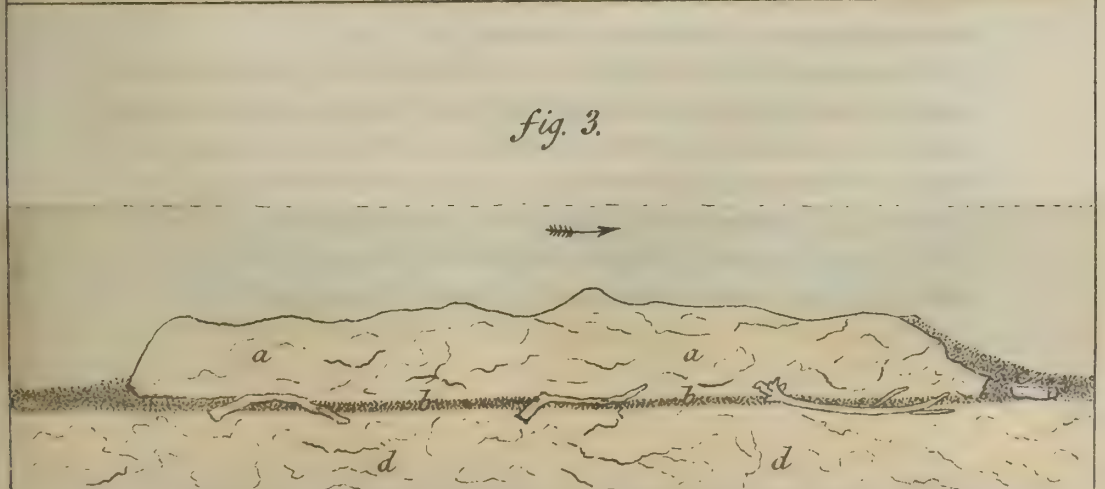
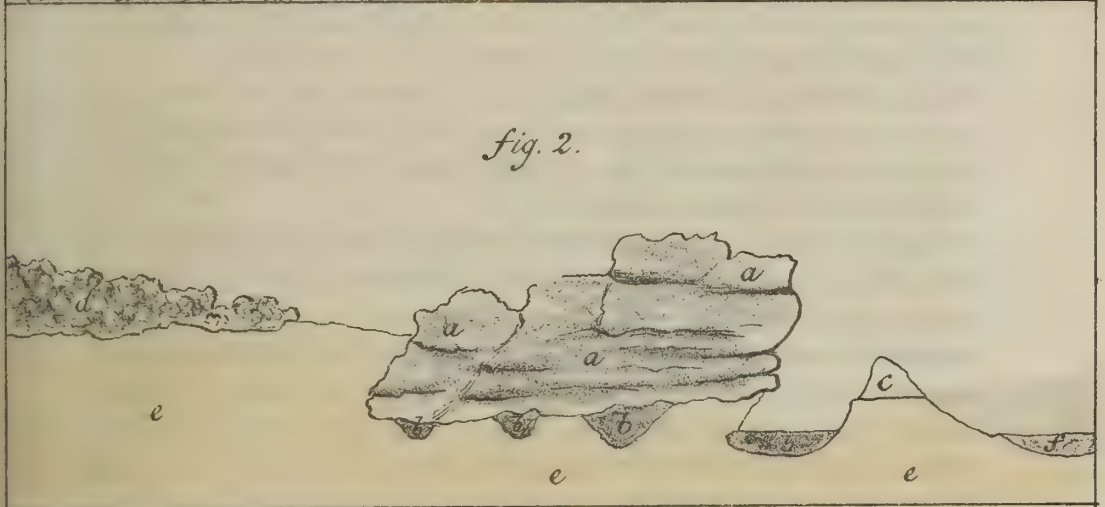
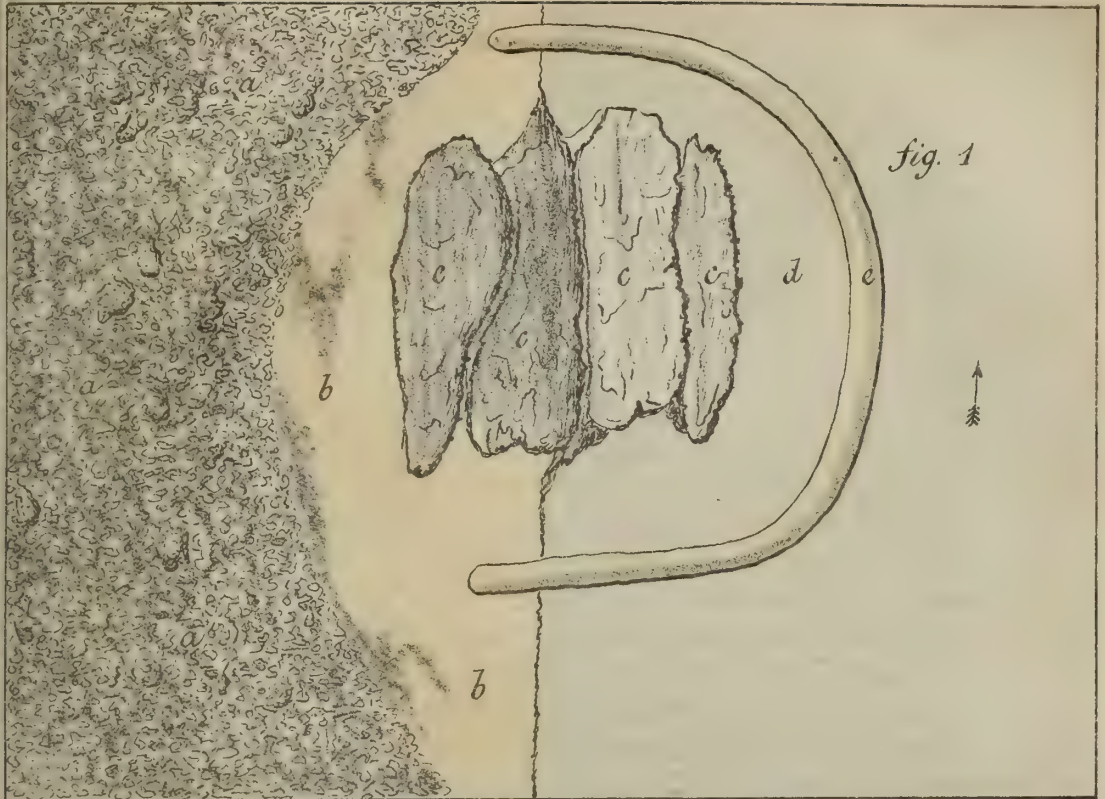
This term (as understood on the Jumna) is applied to four distinct formations, namely—1st, superior sandstone; 2nd, volcanic; 3rd, isolated masses, the remains of beds of nodule kankar, and 4th, conglomerate rocks, composed of kankar and extraneous substances.

1st. *Of the superior Sandstone.* The only strata of this formation occur at intervals between the neighbourhoods of Bárriari and Dhowrie, two villages on the right bank of the river, and near Mhow, a village in the Bundelkhand.

Near Barriári a great deal of good stone for building purposes, and of any dimensions, is quarried, (fig. 1. Pl. 3. spec. 1.) and sent to Allahabad. Very good stones are also procured from many parts of the bank near the above places, by removing two or three feet of loose earth or clay. It is fine grained, and very similar in colour and quality, to that procured from the neighbourhood of Bhurtpore. In fact I believe them to be portions of the same stratum, but am not sufficiently acquainted with the geological features of Bundelkhand (the intervening tract) to make the assertion.

A portion of this stratum, thrown together in large masses by volcanic irruption, forms the curious little rocky island on which a Shiwalá is so picturesquely perched in the centre of the river opposite the village of Dhowrie, about two days' journey from Allahabad.

The other stratum occurs at Mhow only, and extends more than one-third cross the river, and is so friable and coarse as to be totally unfit for any useful purpose. Occupying its present situation, it



has caused infinite trouble, not only by the interruption a body of any sort must be to the navigation in such a place, but by the irregularities of its surface (forming the bed of the river), acting as receptacles for the moving kankar and other extraneous substances passing over it, in which have formed irregular masses of conglomerate rock occupying two-thirds of the whole width of the river. These, perhaps, at the time of their formation did not stand more than a few inches above the bed of the river, (the upper surface of the sandstone rock,) but the river deepening its bed in the course of ages has gradually worn away the sandstone, leaving the masses of conglomerate (on which it can make no impression), in the awkward and dangerous positions which they now occupy, with deep water all round them; and although some of the most dangerous have been removed, the passage down with a side wind is often impracticable to the clumsy boats used on the Jumna. It has this advantage over Karim Khán, (the worst pass in the river,) that the stream is not near so rapid.

Those portions of this stratum which lie near the edge are exposed to the effects of the stream in a minor degree, and stand from one to five feet above the lowest levels, presenting peaks and heads of masses at irregular intervals over a space of about 500 by 200 yards. The exteriors of these are of a dirty green colour, which penetrates about one-eighth of an inch, and is, I imagine, caused by the action of the atmosphere. Under this coating, the natural colour of the stone appears, varying between every tinge of yellow and red, and pure white, which would indicate the presence of some portion of iron; but one sight of the accompanying specimens will convince you, Sir, that but for the presence of some consolidating medium, the sand of itself would never resist the action of any stream. This consolidation occurs in the shape of numerous veins, from one-fourth to two inches in thickness, and from three inches to many feet in width, passing through it in every direction, and rendering it quite impervious to the stream with which it has to contend; and from the feeble attempts of which it is in fact defended by some masses of volcanic origin, which are described below. These veins (spec. 2) are either the deposit of some ferruginous spring, which has had a passage over the stratum, and on which the sand has from time to time accumulated, or is a lignitious lava; they occur in every position, horizontal, vertical, and at every possible angle with each of these: their outer edges are black, and bear a very high polish, produced by the action of the water. The fracture presents an appearance which would justify the conjecture of this substance having passed into the present position in a state of fusion, as it encloses a substance within itself, having a vitrified appearance.

The total absence too of iron within the bounds I am endeavouring to treat of, in any of the alluvial formations, and the intimate connexion existing between the sandstone, and substances of undoubted volcanic origin, strongly incline me to the opinion, that the heat necessary for the production of the latter, might have split the former, and that the interstices thus produced, have filled with the lava, (the present veins,) in a state of fusion. Another circumstance, confirmatory of this, is the fact of the sandstone being in a state of transition with the vitrified substances; but owing to the brittleness of the intermediate substance, (spec. *d.*) it was with the greatest difficulty I could procure the accompanying specimens.

Of the Volcanic Rocks.

These occur in two separate situations, namely, at Murka and Mhow. You will perceive, Sir, that the specimens from the former place, agree with Nos. 4, from the latter, although the shortest distance between these places cannot be less than 20 miles, perhaps more.

The mass at Murka, consisting of rough spheroidal blocks, varying from one by two, to three by five feet, lies on the right bank of the river; their peculiar shape, appearance, and position, leads me to imagine, that they have been ejected in a partially vitrified state, and lodging in the water, the outer and angular parts have become slacked, and have been swept away by the stream, leaving these blocks, which, under these circumstances, are exactly similar to the core of badly burnt lime; in no other way can I account for their peculiar formation, which had it been produced by rolling, the same cause would have scattered them widely, but this has not been the case, as they lie in a clearly defined mass, (fig. 2. Pl. XV.) and in this instance, have no other connexion with any other stratum than being superincumbent.

They correspond exactly with Nos. 4, from Mhow, both in the degree of vitrification, colour, texture, and every thing but position; those at Mhow overlie, but are entirely detached from their bed, (sandstone,) and the same quantity is scattered over a greater space than at Murka. Their exterior is jet black, and so highly polished, that it is impossible to examine them for any length of time when the sun shines, the great light and heat they reflect during the day is peculiarly distressing to the vision. The interior is a mottled dark, and light red, one view of which is conclusive of its volcanic origin. (Specs. 3 and 4.)

Nos. 5, are specimens also from Mhow, the originals, (spec. 5,) occur in very considerable masses, having both sandstone and clay as a base, and standing above it from 1 to 20 feet; the largest of these

fig. 1



fig. 2.



masses is about 45 feet in diameter, of irregular shape and lighter color, than the detached masses, and evidently has not been nearly so much subjected to the action of fire as the latter; they are much softer, and have interstices filled with earthy matter, which has been subjected to great heat, but are only partially vitrified.

This substance either passes into unburnt clay of the 1st alluvial stratum, or the stratum of superior sandstone, on both of which it rests, (Specs. *c* and *d*.)

The singular appearance and conformation of the detached masses could not fail to attach something of the marvellous to them. Native tradition states them to be the stones which the army besieging Lunká, under Ráma and Lutchmun, were enjoined to bring for the purpose of building the celebrated bridge; but enough having been accumulated, messengers were despatched with the news, two of whom posted themselves at Murka and Mhow, two ghauts on the Jumna, and each, *Lungoor* and *Talah*, arriving with his load, hearing the welcome tidings, it was deposited here, and he proceeded lightly on his journey. I had this version from a Brahmin, who begged me, whilst getting my specimens, to remember that such relics should on no account be disturbed.

Of Isolated Masses, the Remains of Beds of Nodule Kankar.

Whenever these remains occur, the river is by their considerable extent generally contracted in its course, causing the water to rush through the narrow but deep passages between isolated masses of what was once one continuous bed.

The passage at Karim Khán (fig. 1, Pl. XVI.) (the point d'appine of the Jamna works,) is now and has been perhaps for centuries, solely affected by the presence of the remains of an extensive bed of nodule kankar, and is at the present moment the worst pass in the river for boats passing downwards at all seasons and upwards in the monsoons. As a description of this is applicable in its general outlines to every locality where these remains occur, I shall confine myself to it.

This bed has originally been and is still partially connected with and resting on the right bank of the river; its surface I imagine to be about 75 or 80 feet below the average level of the Bundelkhand bank, and the bed of the river to be about 16 feet below the surface. The left or Dúab bank is not above two-thirds the height of the opposite one, and is protected by a very extensive shingle shoal; had it been a bank on which the stream would have made any impression, the river would have certainly taken a course more free from impediments than the one it now pursues. The stream being thus confined, has, by the gradual deepening of the river throughout its course, been at last

thrown over this bed of kankar with sufficient force to break it up partially, and the remains present a number of detached masses protruding across two-thirds of the river, from the right bank, standing from four to five feet above the surface of the water at low levels, exposing the whole thickness of the bed, which varies between three and five feet, and an average of two feet of its substratum a stiff clay, and between them deep channels are worn. The action of so rapid a stream on all sides of these bases of clay (the supports of the superincumbent kankar) is gradually but surely reducing them, and in the course of time, becoming too feeble to support its weight. The kankar will be deposited in the bed of the river some 12 or 14 feet lower than its present position.

These masses, which vary from a few feet to many yards in size, are externally very compact and hard; but on penetrating 18 inches, it will be found, that they maintain inside this crust a similar appearance and quality with any bed that might be opened in the centre of the Dúáb, namely, the interstices between the nodules being filled with a loamy clay, and having every appearance of having been undisturbed since the formation of the bed.

It was on the strength of the unsuccessful search I have instituted in and under such strata as this, that I hazarded the opinion that I should consider the slightest discovery of fossil (animal) remains at a level corresponding with the deepest parts of the river, as the merest possible accident: perhaps I should have rather said, fossil remains may possibly be found in the Dúáb general alluvium; but it must be under parallel circumstances with those producing the Jumna fossils, as it is impossible to suppose that during the accumulation of this immense formation that such a space was void of animal life.

The question mooted by GRIFFITHS in speaking of the fossil remains of elephants, "Can we suppose that none are buried there (in climates to which the elephant is native), or that the bones have been decomposed by the force of heat;" chimes so much in tune with the idea that possessed me on examining every excavation in the Dúáb to which I could get access, previous to being acquainted with the section formed by the Jumna, that even now I should feel little difficulty in asserting, that unless some sufficient body intervenes between organic remains and the decomposing power of the sun's rays, soon after their assuming a morbid state, no vestige of them ultimately remains. Experience has proved that they are buried, fossilized, and petrified within the limits of this general alluvium; but in my opinion they are not even cotemporary with this formation, but of a date more recent: for with such an ample section before us, as is presented by the Jumna,



would it be possible, where from the presence of strata of the secondary series, the complete section of the alluvium must be exposed, that within the limits I have examined, not one instance of fossil remains has occurred imbedded in it? To what cause then can their absence be attributed, but that they have been decomposed by the force of heat, before they could attain a state necessary for their preservation? To what then do the present specimens owe their existence? I must suppose either to the interposition of some body (water for instance) between them and the sun's rays, or to their having been petrified in the colder latitudes of the Himálaya, and lodged in the situations from which they were procured by the action of the current.

The fact of their being found in every stage between freshness, fossilization and petrification entirely excludes the idea of their having been uncovered by the deepening of the river having washed among any portion of the secondary strata, by which they would have been exhumed from the stratum in which they had been petrified: had the petrification taken place there, they must have all occupied that position from the known age of the general alluvium; a sufficient time to have been all alike or nearly so, which is not the case.

The following observations made on the conglomerate formation may throw some light on the subject.

The Conglomerate Rocks,

Are composed of nodule kankar and extraneous substances—and consist of two separate formations, both of which are strictly mechanical, together composing one-third of the rocks of the Jumna. Their difference consists in one formation being consolidated by means of cement, the other by the intervention of carbonate of lime deposited whilst in solution in all the interstices of any mass, thus connecting the whole together.

Before proceeding further, it will be necessary to explain how these nodules of kankar and extraneous substances are accumulated, and then show the method of application of the consolidating bodies. In all the high and nearly perpendicular banks of the Jumna, ravines are cut out by heavy runs of water at short and irregular intervals, which serve as drains to the surrounding country. During the heavy periodical rains, considerable bodies of water rush through these ravines with great violence, bringing down drift wood, rubbish of every description, nodule kankar, and large portions of clay detached by the water from the sides and beds of the ravines. The latter generally arrives in the river rolled into figures varying between a prolate ellipsoid and spheroid, (spec. z,) of all sizes, and from 20 lbs. to $\frac{1}{4}$ of an ounce in weight. The clay being softened in its rolling progress,

attaches to its circumference every substance hard enough to make a sufficiently deep impression to secure its hold; this continues until every portion of the outer surface is covered, when, of course, the accumulation ceases; in this state it is washed from the ravine into the bed of the river, on reaching which, it is carried forward in a new direction of the current of the river, which deposits it in the nearest hollow in its bed, where after lying a sufficient time, the body disunites; the lighter earthy particles are swept away by the stream, whilst the clay kankar, and other substances which may have been brought down with them, remain as deposited there: thus are all the necessary ingredients at once provided for the formation of a conglomerate rock except the sand, which in the course of a few hours generally proves the most abundant article of the composition, when only a sufficient time for the cement to set is necessary to present a rock, which the carbonate of lime (which fills all interstices that may be left) ultimately renders the hardest, and from their situation, very frequently the most dangerous rocks of the Jumna. (Specs. 6.)

The conglomerate in which carbonate of lime is the consolidating medium is generally produced by the breaking up of the beds of nodule kankar, by the supporting pillar of clay (its substratum) being washed away, or other causes, the loose or interior nodules, of which are then deposited in the nearest hollow lower down the stream that can detain them, when from the absence of clay (excepting this dislodgement occurs in the monsoon), the cement cannot be produced, and the deposit remains until by the usual process of tufa formation, the whole becomes one consolidated mass, (spec. 8.) this, however, must be the work of time, during which, sand often fills many of the interstices, and becomes a part of the conglomerate body.

The fractured edges of remains of nodule kankar beds often present this formation, although from the difficulties it has to encounter, a very small proportion of the conglomerate rocks of the Jumna belong to this class. The principal tufa formation that I am acquainted with, was removed by Lieut. MARTIN, Engineers, from near the village of Orowal, where the accompanying specimens were collected. (Spec. 8.)

Most of the specimens in your hands, Sir, will speak for themselves. I select, however, one instance of the cement formation, in which the fossil remains of an elephant are imbedded, which I consider, claims a particular description.

The site of the mass containing these interesting remains on the right bank of the river, about 12 miles from Korah Jehánábád on the high road to Cawnpur, directly under the village of Pachkowie, which stands nearly 80 feet above it, lying amongst an immense as-